

SCXI™-1125

Introduction

This document contains information and step-by-step instructions for verifying and calibrating the National Instruments SCXI-1125 signal conditioning module.

What Is Calibration?

Calibration is a procedure of reading offset and gain errors from a device and updating special analog calibration circuitry that corrects these errors. National Instruments calibrates every SCXI-1125 module at the factory. During the factory calibration process, the calibration constants are stored in the non-volatile memory of the device. These values are loaded from memory and used as needed by the device.

Why Should You Calibrate?

Offset and gain errors drift with time and temperature changes, which could invalidate the factory-set calibration of a device and increase measurement uncertainty. Calibration restores the device to its specified accuracy.

How Often Should You Calibrate?

The measurement accuracy requirements of your application determine how often you should calibrate your SCXI-1125 module. National Instruments recommends you perform a complete calibration at least once every year. You can shorten this interval to six months or 90 days, based on the demands of your application.

Equipment and Other Test Requirements

This section describes the equipment, software, documentation, and test conditions required for calibrating the SCXI-1125.

Test Equipment

Calibration requires a high-precision voltage source with at least 50 ppm accuracy, a multiranging 5 1/2 digit digital multimeter (DMM) with 15 ppm accuracy, and a National Instruments E Series DAQ device.

National Instruments recommends the following instruments for calibrating the SCXI-1125:

- Calibrator—Fluke 5700A
- DMM—NI 4060 or HP 34401A
- National Instruments E Series DAQ device

If these instruments are not available, use the accuracy requirements listed above to select a substitute calibration standard.



Note If you do not have custom connection hardware, you will need a connector block such as the National Instruments SCXI-1320, a shielded 68-pin connector cable, a 50-pin ribbon cable, a 50-pin breakout box, and an SCXI adapter. These components give easy access to the individual pins on the SCXI-1125 front and rear connectors.

Software and Documentation

You will need the following software and documentation to calibrate the SCXI-1125 signal conditioning modules. You can find these on the National Instruments Web site at ni.com/calibration:

- The latest version of the National Instruments NI-DAQ driver
- *NI-DAQ Function Reference Online Help* file
- *NI-DAQ User Manual for PC Compatibles*

Software

The SCXI-1125 calibration procedure requires the latest version of the National Instruments NI-DAQ driver on the calibration system. The driver supports a number of programming languages, including LabVIEW, LabWindows/CVI, Microsoft Visual C++, Microsoft Visual Basic, and Borland C++. When you install the driver, you only need to install support for the programming language you will use.

Documentation

The *NI-DAQ Function Reference Online Help* file and *NI-DAQ User Manual for PC Compatibles* contain detailed information on using the NI-DAQ driver. The function reference online help file includes detailed information on the driver functions. You can access the online help by clicking **Start»Programs»National Instruments DAQ»NI-DAQ Help**. The user manual provides instructions on installing and configuring National Instruments DAQ devices. This manual also includes detailed information on creating applications that use the NI-DAQ driver. These are your primary references for writing your calibration utility. For further information on the products you are calibrating, refer to your device user manuals.

Test Conditions

Follow these guidelines to optimize the connections and the environment during calibration:

- Keep connections to the SCXI module short. Long cables and wires act as antennae, picking up extra noise and thermal offsets that can affect measurements.
- Use shielded copper wire for all cable connections to the device. Use twisted-pair wire to eliminate noise and thermal offsets.
- Maintain the temperature between 18 and 28 °C.
- Keep relative humidity below 80%.
- Allow a warm-up time of at least 15 minutes for the SCXI module and 30 minutes for the E Series device to ensure the measurement circuitry is at a stable operating temperature.

Calibration

The calibration process consists of the following steps:

1. Setting up the device for testing.
2. Verifying the existing operation of the device to determine whether it is operating within its specifications.
3. Adjusting the device with respect to a known voltage source.
4. Verifying that the device is operating within its specifications after adjustments.

Setting Up Your Module

Complete the following steps to set up your module for testing:

1. Install the SCXI-1125 in slot 1 of the SCXI chassis.
2. Connect a 68-to-68-pin cable between the SCXI module and the E Series DAQ device installed in the host computer.
3. Configure the hardware with Measurement & Automation Explorer (MAX). For more information on configuring the system, refer to the E Series device and SCXI module documentation.

Verifying Gain and Offset Errors

The verification procedure determines how well the SCXI-1125 module is meeting its specifications. You can use this information to select the appropriate calibration interval for your application.

Complete the following steps to verify gain and offset errors in the SCXI-1125:

1. Read the *Test Conditions* section earlier in this document.
2. Refer to the specifications in Table 1 at the end of this document.
3. Connect the E Series device to the SCXI-1125.
4. Call `Calibrate_E_Series` to minimize the uncertainty associated with the E Series device measurements. Set the following parameters:
 - **deviceNumber**—The value assigned by MAX
 - **calOp**—`ND_SELF_CALIBRATE`
 - **setOfCalConstants**—`ND_USER_EEPROM_AREA`
 - **calRefVolts**—0.0
5. Call `AI_Configure` to put the E Series device in bipolar mode. Set the following parameters:
 - **deviceNumber**—The value assigned by MAX
 - **chan**—0
 - **inputMode**—0
 - **inputRange**—0
 - **polarity**—0
 - **driveAIS**—0
6. Call `MIO_Config` to enable dithering on the E Series device. Set the following parameters:
 - **deviceNumber**—The value assigned by MAX
 - **dither**—1
 - **useAMUX**—0

7. Connect the calibrator to the appropriate analog input, starting with channel 0. Refer to Figure 1 to determine which pins on the 96-pin front connector correspond to the positive and negative inputs of the specified channel. For example, the positive input for channel 0 (CH0+) is pin A32. The negative input for channel 0 (CH0-) is pin C32. If you are using an SCXI-1320 terminal block connected to the SCXI-1125, connect the calibrator to the CH0+ and CH0- inputs.
8. Call `SCXI_Single_Chan_Setup` to configure the module for single-channel measurements. Set the following parameters:
 - **SCXIchassisID**—The value assigned by MAX
 - **moduleSlot**—1
 - **moduleChan**—The same channel number from step 7
 - **DAQdeviceNumber**—The device number assigned by MAX for the E Series DAQ device
9. Call `SCXI_Set_Gain` to set the gain you want to test on the module. Set the following parameters:
 - **SCXIchassisID**—The ID obtained when the chassis is configured with MAX
 - **moduleSlot**—1
 - **channel**—The channel number from step 7
 - **gain**—The first gain value you want to test—you can find this gain value in Table 1.
10. Call `SCXI_Configure_Filter` to configure the filter setting on the module. Set the following parameters:
 - **SCXIchassisID**—The ID obtained when the chassis is configured with MAX
 - **moduleSlot**—1
 - **channel**—The channel number from step 7
 - **filterMode**—1
 - **cutoffFrequency**—10,000
11. Set the calibrator to output the test point voltage from Table 1.
12. Call `DAQ_Op`. Set the following parameters:
 - **deviceNumber**—The device number of the DAQ device
 - **channel**—0
 - **gain**—1 for 16-bit E Series devices or -1 for 12-bit E Series devices
 - **count**—5,000
 - **sampleRate**—10,000

13. Call `SCXI_Scale`. Set the following parameters:
 - **SCXIChassisID**—The value assigned by MAX
 - **moduleSlot**—1
 - **channel**—The same channel number from step 7
 - **SCXIgain**—The same gain value from step 9
 - **TBgain**—1
 - **DAQboard**—The device number for the DAQ device
 - **DAQChannel**—0
 - **DAQgain**—1 for 16-bit devices, -1 for 12-bit devices
 - **numPoints**—5.000
 - **binArray**—The **array** returned from the `DAQ_Op` function

The result is a set of scaled voltages that you read from the SCXI module.

14. Average the results returned from the `SCXI_Scale` function. Compare the averaged result to the upper and lower limits in Table 1. If the result falls within these limits, your module has passed this portion of the test. If it does not, your module needs to be adjusted using the steps in the next section, *Adjusting for Gain and Offset Errors*.
15. Repeat steps 8 through 14 for the remaining gains.
16. Repeat steps 7 through 15 for the remaining channels.

You have now finished verifying your SCXI-1125.



Note If all channels fall within the upper and lower limits, your device does not need to be adjusted.

Adjusting for Gain and Offset Errors

The following two sections explain how to determine the gain and offset errors of your SCXI-1125 and how to adjust the calibration constants to correct for these errors.

Determining Gain and Offset Errors

Complete the following steps to determine the gain and offset errors of the SCXI-1125:

1. Read the *Test Conditions* section.
2. Connect the E Series device to the SCXI-1125.
3. Call `Calibrate_E_Series` to minimize the uncertainty associated with the E series device measurements. Set the following parameters:
 - **deviceNumber**—The value assigned by MAX

- **calOp**—ND_SELF_CALIBRATE
 - **setOfCalConstants**—ND_USER_EEPROM_AREA
 - **calRefVolts**—0.0
4. Call `AI_Configure` to put the E Series device in bipolar mode. Set the following parameters:
 - **deviceNumber**—The value assigned by MAX
 - **chan**—0
 - **inputMode**—0
 - **inputRange**—0
 - **polarity**—0
 - **driveAIS**—0
 5. Call `MIO_Config` to enable dithering on the E Series device. Set the following parameters:
 - **deviceNumber**—The value assigned by MAX
 - **dither**—1
 - **useAMUX**—0
 6. Call `SCXI_Single_Chan_Setup` to configure the module for single-channel measurements. Set the following parameters:
 - **SCXIchassisID**—The value assigned by MAX
 - **moduleSlot**—1
 - **moduleChan**—The channel you want to adjust
 - **DAQdeviceNumber**—The device number assigned by MAX for the E Series DAQ device
 7. Call `SCXI_Set_Gain`. Set the following parameters:
 - **SCXIchassisID**—The ID of the SCXI chassis obtained when you configure the chassis with MAX
 - **moduleSlot**—1, because the SCXI-1125 should be installed in slot 1
 - **channel**—The same channel number from step 6
 - **gain**—The gain value you want to adjust. Refer to Table 1 for acceptable gain values
 8. Call `SCXI_Configure_Filter` to configure the filter setting on the module. Set the following parameters:
 - **SCXIchassisID**—The ID of the SCXI chassis obtained when you configure the chassis with MAX
 - **moduleSlot**—1
 - **channel**—The same channel number from step 7

- **filterMode**—1
 - **cutoffFrequency**—10,000
9. Connect the calibrator to the analog input you want to adjust. Refer to Figure 1 to determine the pins on the 96-pin front connector that correspond to the positive and negative inputs of the specified channel. For example, the positive input for channel 0 is pin A32, which is labeled CH0+. The negative input for channel 0 is pin C32, which is labeled CH0-. If you are using an SCXI-1320 terminal block connected to the SCXI-1125, connect the calibrator to the CH0+ and CH0- inputs.
 10. Connect the DMM to the positive output on pin 3 (MCH0+) and negative output on pin 4 (MCH0-) on the rear panel connector. Figure 2 shows the 50-pin rear panel connector.



Tip For easy access to individual pins, use a screw terminal adapter connected to a 50-pin terminal block.

11. Set the calibrator voltage to the positive test point value in Table 1.
12. Read the voltage from the DMM. Record the actual DMM reading, which is *output1*, and the calibrator output voltage, which is *volt1*, for later use.
13. Set the calibrator to the negative test point value for the same gain. Skip any input limits that are specified as 0.0 V. You need only upper and lower limits for adjustment.
14. Read the voltage from the DMM. Record the actual DMM reading, *output2*, and the calibrator output voltage, *voltage2*.
You now have two pairs of data points, (*volt1*, *output1*) and (*volt2*, *output2*), where *volt* is the calibrator reading and *output* is the DMM reading.
15. Convert the DMM voltage readings (*output1* and *output2*) to binary readings (*binary1* and *binary2*) by using one of the following equations:

$$\text{binary reading for 12-bit E Series products (binary)} = \left(\frac{\text{output}}{20} \right) \times 2^{12}$$

$$\text{binary reading for 16-bit E Series products (binary)} = \left(\frac{\text{output}}{20} \right) \times 2^{16}$$

For example, using a 12-bit product such as a PCI-MIO-16E-1 and obtaining a DMM reading of -9.9 V, you would have the following results:

$$\text{binary reading} = (-9.9/20) \times 2^{12} = -2027.52$$

16. Record *binary1* with *volt1* and *binary2* with *volt2* for later use.
17. Repeat steps 7 through 16 for the remaining gain values you want to adjust on this channel.
18. Repeat steps 6 through 17 for the remaining channels you want to adjust.

You have determined the new calibration constants. Use these values in the the following section, *Adjusting Calibration Constants*.

Adjusting Calibration Constants

Complete the following steps to adjust the calibration constants on the SCXI-1125:

1. Call `SCXI_Cal_Constants` to create and store the new calibration constants in the SCXI-1125 memory. Set the following parameters:
 - **SCXIchassisID**—The ID assigned by MAX
 - **ModuleSlot**—1, because the SCXI-1125 should be installed in slot 1
 - **channel**—The channel on the SCXI-1125 you want to adjust
 - **OpCode**—2
 - **calibrationArea**—0
 - **rangeCode**—0 (not used for the SCXI-1125)
 - **SCXIgain**—The gain you want to adjust
 - **DAQboard**—The device number assigned by MAX
 - **DAQChan**—0
 - **DAQGain**—1 for 16-bit devices, -1 for 12-bit devices
 - **Tbgain**—1.0
 - **volt1** and **volt2**—The first and second voltage readings for the gain values that you are about to save on the SCXI-1125
 - **binary1** and **binary2**—The first and second binary readings for the gain values that you are about to save on the SCXI-1125
 - **calConst1** and **calConst2**—These are return values
2. Repeat step 1, changing **calibrationArea** to 1.
3. Repeat steps 1 and 2 for the next channel.

You have now finished adjusting the calibration constants of your SCXI-1125.

Verifying Adjusted Values

After completing the adjustments to your SCXI-1125 module, it is important that you verify the analog input operation by repeating the steps listed in the *Verifying Gain and Offset Errors* section of this document. Re-verifying after adjustments ensures that your SCXI-1125 module is now operating within its specifications.

Front and Rear Signal Connector Diagrams

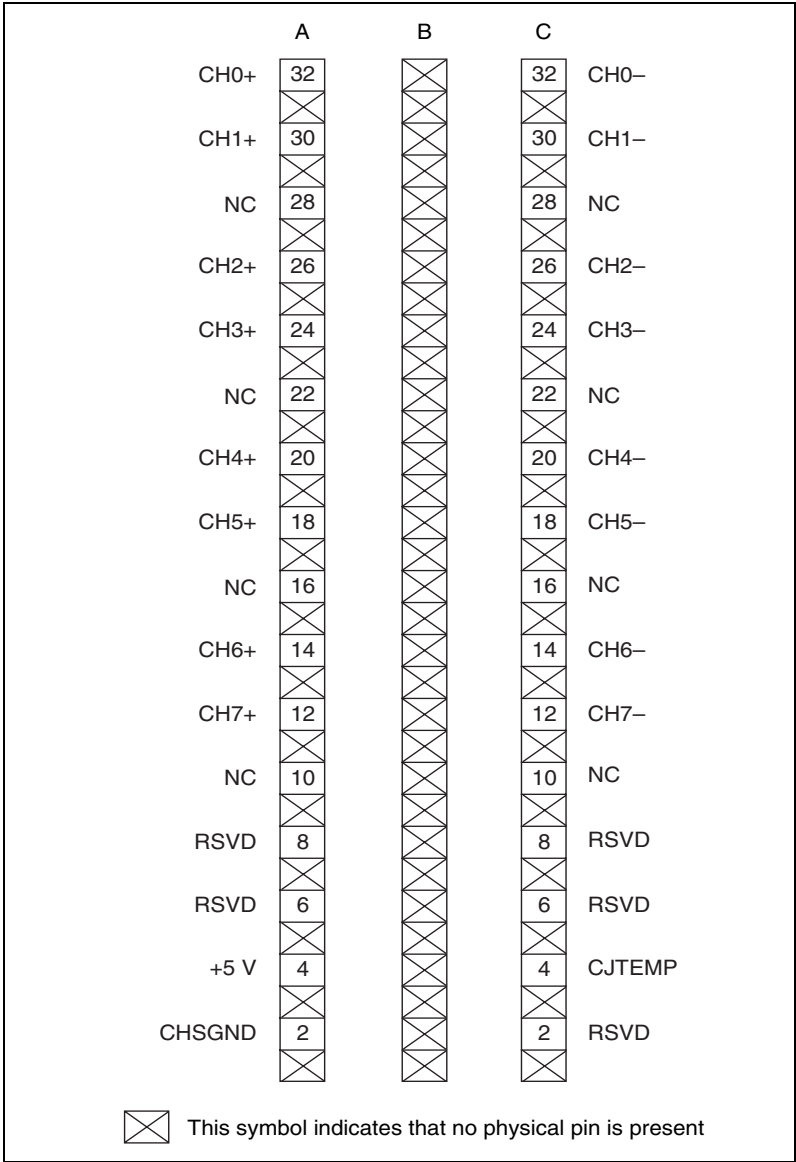


Figure 1. Front Signal Connector Pin Assignments

AOGND	1	2	AOGND
MCH0+	3	4	MCH0-
MCH1+	5	6	MCH1-
MCH2+	7	8	MCH2-
MCH3+	9	10	MCH3-
MCH4+	11	12	MCH4-
MCH5+	13	14	MCH5-
MCH6+	15	16	MCH6-
MCH7+	17	18	MCH7-
OUTREF	19	20	
	21	22	
	23	24	DIGGND
SERDATIN	25	26	SERDATOUT
DAQD*/A	27	28	
SLOT0SEL*	29	30	
	31	32	
DIGGND	33	34	
	35	36	SCANCLK
SERCLK	37	38	
	39	40	
	41	42	
	43	44	
	45	46	SYNC
	47	48	
	49	50	

Figure 2. Rear Signal Connector Pin Assignments

Specifications

The following table contains the specifications you should use when verifying and calibrating your SCXI-1125 module. If your device has been calibrated within the last year, the test point value should fall between the *Upper Limit* and *Lower Limit* values.

Table 1. SCXI-1125 Specifications at 25 °C ±10 °C

Gain	Range	Test Point	Upper Limit (V)	Lower Limit (V)
1	5	4.950000	4.9623181	4.9376819
1	0	0.000000	0.005002	-0.005002
1	-5	-4.950000	-4.9376819	-4.9623181
2	2.5	2.475000	2.4811601	2.4688400
2	0	0.000000	0.002502	-0.002502
2	-2.5	-2.475000	-2.4688400	-2.4811601
5	1	0.990000	0.9924652	0.9875348
5	0	0.000000	0.001002	-0.001002
5	-1	-0.990000	-0.9875348	-0.9924652
10	0.5	0.495000	0.4962336	0.4937664
10	0	0.000000	0.000502	-0.000502
10	-0.5	-0.495000	-0.4937664	-0.4962336
20	0.25	0.247500	0.24811781	0.24688220
20	0	0.000000	0.000252	-0.000252
20	-0.25	-0.247500	-0.24688220	-0.24811781
50	0.1	0.099000	0.09924832	0.09875168
50	0	0.000000	0.000102	-0.000102
50	-0.1	-0.099000	-0.09875168	-0.09924832
100	0.05	0.0495000	0.04962516	0.04937484
100	0	0.000000	0.000052	-0.000052
100	-0.05	-0.049500	-0.04937484	-0.04962516
200	0.025	0.024750	0.02481358	0.02468642
200	0	0.000000	0.000027	-0.000027

Table 1. SCXI-1125 Specifications at 25 °C ±10 °C (Continued)

Gain	Range	Test Point	Upper Limit (V)	Lower Limit (V)
200	-0.025	-0.024750	-0.02468642	-0.02481358
250	0.02	0.019800	0.01985126	0.01974874
250	0	0.000000	0.000022	-0.000022
250	-0.02	-0.019800	-0.01974874	-0.01985126
500	0.01	0.009900	0.00992663	0.00987337
500	0	0.000000	0.000012	-0.000012
500	-0.01	-0.009900	-0.00987337	-0.00992663
1000	0.005	0.00495	0.00496432	0.00493568
1000	0	0.000000	0.000007	-0.000007
1000	-0.005	-0.004950	-0.00493568	-0.00496432
2000	0.0025	0.002475	0.00248316	0.00246684
2000	0	0.000000	0.000005	-0.000005
2000	0.0025	-0.002475	-0.00246684	-0.00248316
Limits Valid for 4 Hz or 10 kHz Filter Settings				
Valid when using an MIO device after performing an MIO internal calibration.				
Valid for both filter settings with 5.000 point averaging at 10,000 samples per second.				